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Claims

1. A method for calibrating an interferometer optics for measuring optical surfaces, said method comprising:

   arranging a first substrate having a first surface and a second surface opposite said first surface in a beam path of a first incident beam provided by said interferometer optics with said first surface facing towards said first incident beam, and interferometrically taking a first measurement of first wave fronts generated by reflecting said first incident beam from said second surface of said first substrate;

   arranging said first substrate in said beam path of said first incident beam with said second surface facing towards said first incident beam, and interferometrically taking a second measurement of second wave fronts generated by reflecting said first incident beam from said second surface of said first substrate;

   arranging a third surface of a second substrate in a beam path of a second incident beam, and interferometrically taking a third measurement of third wave fronts generated by reflecting said second incident beam from said third surface of said second substrate, while said first substrate

is not arranged in said beam path of said second incident beam;

arranging said third surface of said second substrate and said first substrate in said beam path of said second incident beam, and interferometrically taking a fourth measurement of fourth wave fronts generated by reflecting said second incident beam from said third surface and through said first substrate; and

determining optical properties of said interferometer optics in dependence of said first, second, third and fourth measurements.

2. The method according to claim 1, wherein said second incident beam is provided by said interferometer optics.

3. The method according to claim 1, wherein said first and second surfaces of said first substrate and said third surface of said second substrate are substantially flat surfaces and wherein light of said first and second incident beams has substantially flat wave fronts.

4. The method according to claim 1, wherein said first and second surfaces of said first substrate and said third surface of said second substrate are substantially spherical surfaces and wherein light of said first and second incident beams has substantially spherical wave fronts.

5. The method according to claim 1, wherein said first substrate is of a wedge shape.

6. The method according to claim 1, wherein said interferometer has an optical axis and wherein said optical properties are rotationally symmetric properties with respect to said optical axis.

7. The method according to claim 1, wherein said second measurement is taken by superimposing said second wave fronts with first reference wave fronts generated by reflecting said first incident beam from a reference surface of said interferometer optics.

8. The method according to claim 1, wherein said third measurement is taken by superimposing said third wave fronts with second reference wave fronts generated by reflecting said second incident beam from a reference surface.

9. The method according to claim 1, wherein said fourth measurement is taken by superimposing said fourth wave fronts with second reference wave fronts generated by reflecting said second incident beam from a reference surface.

10. The method according to claim 1, wherein said first measurement is taken by superimposing said first wave fronts with first reference wave fronts generated by reflecting said first incident beam from a reference surface of said interferometer optics.

11. The method according to claim 10, wherein said optical properties of said interferometer optics substantially correspond to phase differences determined by a formula

Wint = 1/2 (W2 + W3 + W4 - W5),

wherein:

Wint represents said phase differences of said interferometer optics,

W2 represents phase differences determined from said first measurement,

W3 represents phase differences determined from said second measurement,

W4 represents phase differences determined from said third measurement, and

W5 represents phase differences determined from said fourth measurement.

12. The method according to claim 1, wherein said first measurement is taken by superimposing said first wave fronts with fifth wave fronts generated by reflecting said first incident beam from said first surface of said first substrate.

13. The method according to claim 12, further comprising:

arranging said first substrate in said beam path of said first incident beam with said first surface facing towards said first incident beam, and interferometrically taking a fifth measurement of sixth wave fronts generated by reflecting said first incident beam from said first surface; and

wherein said optical properties of said interferometer optics substantially correspond to phase differences determined by a formula

Wint = 1/2 (W1 + Wfr + W3 + W4 - W5),

wherein:

Wint represents said phase differences of said interferometer optics,

W1 represents phase differences determined from said fifth measurement,

Wfr represents phase differences determined from said first measurement,

W3 represents phase differences determined from said second measurement,

W4 represents phase differences determined from said third measurement, and

W5 represents phase differences determined from said fourth measurement.

14. A method for processing a substrate having an optical surface, said method comprising:

arranging a first substrate having a first surface and a second surface opposite said first surface in a beam path of a first incident beam with said first surface facing towards said first incident beam, and interferometrically taking a first measurement of first wave fronts generated by reflecting said first incident beam from said second surface of said first substrate;

arranging said first substrate in said beam path of said first incident beam with said second surface facing towards said first incident beam,

and interferometrically taking a second measurement of second wave fronts generated by reflecting said first incident beam from said second surface of said first substrate;

arranging a third surface of a second substrate in a beam path of a second incident beam, and interferometrically taking a third measurement of third wave fronts generated by reflecting said second incident beam from said third surface of said second substrate, while said first substrate is not arranged in said beam path of said second incident beam;

arranging said third surface of said second substrate and said first substrate in said beam path of said second incident beam, and interferometrically taking a fourth measurement of fourth wave fronts generated by reflecting said second incident beam from said third surface and through said first substrate; and

determining deviations of said optical surface from a target shape thereof in dependence of said first, second, third and fourth measurements.

15. The method according to claim 14, wherein said optical surface is said third surface of said second substrate.

16. The method according to claim 15, wherein said determined deviations correspond to calculated deviations substantially determined by a formula:

$$hM = 1/4\ (-\ W2 - W3 + W4 + W5) - h_{iM}$$

wherein:

hM represents said calculated deviations,

W2 represents phase differences determined from said first measurement,

W3 represents phase differences determined from said second measurement,

W4 represents phase differences determined from said third measurement,

W5 represents phase differences determined from said fourth measurement, and

h_{iM} represents a predetermined input offset.

17. The method according to claim 14, wherein said optical surface to be qualified or manufactured, respectively, is said second surface of said first substrate.

18. The method according to claim 17, wherein said determined deviations correspond to calculated deviations substantially determined by a formula:

$$h2 = 1/4\ (-\ W2 + W3 - W4 + W5) - h_{i2}$$

wherein:

h2 represents said calculated deviations,

W2 represents phase differences determined from said first measurement,

W3 represents phase differences determined from said second measurement,

W4 represents phase differences determined from said third measurement,

W5 represents phase differences determined from said fourth measurement, and

h_{i2} represents a predetermined input offset.

19. The method according to claim 14, further comprising:

arranging a fourth optical surface of a third substrate in said beam path of said first incident beam, and interferometrically taking a sixth measurement of seventh wave fronts generated by reflecting said first incident beam from said optical surface;

20. The method according to claim 19, wherein said optical surface to be qualified or manufactured, respectively, is said fourth surface of said third substrate.

21. The method according to claim 20, wherein said determined deviations correspond to calculated deviations substantially determined by a formula:

$$h0 = 1/4\ (-W2 - W3 - W4 + W5 + 2\ W6) - h_{i0}$$

wherein:

h0 represents said calculated deviations,

W2 represents phase differences determined from said first measurement,

W3 represents phase differences determined from said second measurement,

W4 represents phase differences determined from said third measurement,

W5 represents phase differences determined from said fourth measurement,

W6 represents phase differences determined from said sixth measurement, and

h_{i0} represents a predetermined input offset.

22. The method according to claim 14, further comprising arranging said first substrate in said beam path of said first incident beam with said first surface facing towards said first incident beam, and

interferometrically taking a fifth measurement of sixth wave fronts generated by reflecting said first incident beam from said first surface.

23. The method according to claim 22, wherein said optical surface to be qualified or manufactured, respectively, is said first surface of said first substrate.

24. The method according to claim 23, wherein said determined deviations correspond to calculated deviations substantially determined by a formula:

$$h1 = 1/4\ (2\ W1 - W2 - W3 - W4 + W5) - h_{i1}$$

wherein:

h1 represents said calculated deviations,

W1 represents phase differences determined from said fifth measurement,

W2 represents phase differences determined from said first measurement,

W3 represents phase differences determined from said second measurement,

W4 represents phase differences determined from said third measurement,

W5 represents phase differences determined from said fourth measurement, and

h_{i1} represents a predetermined input offset.

25. The method according to claim 14, wherein said first measurement is taken by superimposing said first wave fronts with fifth wave fronts generated by reflecting said first incident beam from said first surface of said first substrate.

26. The method according to claim 25, further comprising arranging said first substrate in said beam path of said first incident beam with said first surface facing towards said first incident beam, and interferometrically taking a fifth measurement of sixth wave fronts generated by reflecting said first incident beam from said first surface.

27. The method according to claim 26, wherein said optical surface to be qualified or manufactured, respectively, is said first surface of said first substrate and wherein said determined deviations correspond to calculated deviations substantially determined by a formula:

$$h1 = 1/4\ (W1 - Wfr - W3 - W4 + W5) - h_{i1}$$

wherein:

h1 represents said calculated deviations,

W1 represents phase differences determined from said fifth measurement,

Wfr represents phase differences determined from said first measurement,

W3 represents phase differences determined from said second measurement,

W4 represents phase differences determined from said third measurement,

W5 represents phase differences determined from said fourth measurement, and

h_{i1} represents a predetermined input offset.

28. The method according to claim 26, wherein said optical surface to be qualified or manufactured, respectively, is said second surface of said first substrate and wherein said determined deviations correspond to

calculated deviations substantially determined by a formula:

$$h2 = 1/4\ (-\ W1 - Wfr + W3 - W4 + W5) - h_{i2}$$

wherein:

h2 represents said calculated deviations,

W1 represents phase differences determined from said fifth measurement,

Wfr represents phase differences determined from said first measurement,

W3 represents phase differences determined from said second measurement,

W4 represents phase differences determined from said third measurement,

W5 represents phase differences determined from said fourth measurement, and

h_{i2} represents a predetermined input offset.

29. The method according to claim 26, wherein said optical surface to be qualified or manufactured, respectively, is at least one of said first surface of said first substrate and said second surface of said first substrate and wherein said determined deviations correspond to calculated values substantially determined by a formula:

$$D = 1/2\ (W5 - W4 - Wfr) + hi$$

wherein:

D represents said calculated values,

Wfr represents phase differences determined from said first measurement,

W4 represents phase differences determined from said third measurement,

W5 represents phase differences determined from said fourth measurement, and

hi represents a predetermined input offset.

30. The method according to claim 25, wherein said optical surface to be qualified or manufactured, respectively, is at least one of said first surface of said first substrate and said second surface of said first substrate and wherein said determined deviations correspond to calculated values substantially determined by a formula:

$$i = n \cdot (W_5 - W_4) - (n - 1) \cdot W_{fr}$$

wherein:

i represents said calculated values,
Wfr represents phase differences determined from said first measurement,
W4 represents phase differences determined from said third measurement,
W5 represents phase differences determined from said fourth measurement, and
n represent an average index of refraction of a material of said first substrate.

31. The method according to claim 14, further comprising:

(j) machining said optical surface in dependence of said determined deviations.

32. The method according to claim 31, wherein said machining is only performed if said deviations exceed a predetermined threshold.

33. The method according to claim 31, wherein said determining of deviations and said machining are repeatedly performed.

34. The method according to claim 31, further comprising a finishing of said optical surface.

35. The method according to claim 34, wherein said finishing comprises applying a coating to said optical surface.

36. The method according to claim 35, wherein said coating comprises at least one of a reflective coating, an anti-reflective coating and a protective coating.

37. The method according to claim 14 wherein processing the substrate comprises manufacturing the substrate.

38. The method according to claim 14 wherein processing the substrate comprises qualifying the substrate.